1922
T67

A STUDY OF THE USE OF SUPERHEATED AND UNSUPERHEATED PLAIN CONDENSED BULK SKIM MILK IN THE MANUFACTURE OF ICE CREAM

BY

PAUL HUBERT TRACY

B. S. University of Illinois, 1920

THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF MASTER OF SCIENCE IN DAIRY
HUSBANDRY IN THE GRADUATE SCHOOL
OF THE UNIVERSITY
OF ILLINOIS, 1922

URBANA, ILLINOIS

Digitized by the Internet Archive
in 2015

https://archive.org/details/studyofuseofsupe00trac

1922
T67

UNIVERSITY OF ILLINOIS

THE GRADUATE SCHOOL

May 15, 1922

I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY Paul Hubert Tracy

ENTITLED A STUDY OF THE USE OF SUPERHEATED AND UNSUPERHEATED PLAIN CONDENSED BULK SKIM MILK IN THE MANUFACTURE OF ICE CREAM

BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE OF Master of Science in Dairy Husbandry

O. R. Overman.
In Charge of Thesis

H. A. Ruehe
Head of Department

Recommendation concurred in*

Committee on Final Examination*

*Required for doctor's degree but not for master's

499052

CONTENTS

	Page
Introduction	1
Definitions	4
Object of the Investigation	6
Plan of Work	6
Experimental Results	19
Conclusions	36
References	37
Acknowledgment	38

A STUDY OF THE USE OF SUPERHEATED AND UNSUPERHEATED PLAIN CONDENSED BULK SKIM MILK IN THE MANUFACTURE OF ICE CREAM

I N T R O D U C T I O N

Plain condensed bulk milk is a product made from either whole, partly whole, or skim milk and is used for the most part to supply the necessary solids in the manufacture of ice cream.

As defined by Hunziker (1), "plain condensed bulk milk is an unsweetened condensed milk made from whole milk, or partly or wholly skimmed milk, condensed in vacuo at the ratio of about three or four parts of fluid milk to one part of condensed milk. It is usually superheated to swell and thicken it and has the consistency of rich cream. It is sold in ten-gallon milk cans to ice cream factories and in milk bottles to the direct consumer. Plain condensed milk is not sterile nor is it preserved by sucrose."

While the condensed milk used in this investigation comes under the above classification, a more specific definition may be given as follows:

Superheated plain condensed bulk skim milk is the unsweetened condensed milk made from completely skimmed whole milk condensed in vacuo at the ratio of about three parts of fluid milk to one part of condensed milk, followed by heating to a temperature from 180° - 190° F. and holding at that temperature for a sufficient length of time to give the body of the condensed milk a heavy consistency. The product is not sterile.

The same definition holds for the unsuperheated milk except that the latter is not subjected to a high temperature to thicken it. Like the superheated milk, it is not a sterile product.

Composition of the Condensed Milk

Assuming that the milk solids not fat in condensed milk are present in the same proportion in which they occur in skim milk, the average composition

of superheated and unsuperheated condensed may be computed from the average composition of skim milk, providing the condensation factor is known. Two authorities give the average composition of skim milk as follows:

	Van Slyke (1)	Richmond (5)
Fat	.1 %	.12%
Casein. . .	2.75	3.22
Albumin . .	.80	.42
Sugar . . .	5.25	4.88
Ash	.80	.78
Total Solids . .	9.7%	9.52%
Water	90.3	90.48
	100 %	100 %

It will be noted that these two authors disagree chiefly as to the proportions of casein, albumin and sugar. Professor O. R. Overman of the Illinois Experiment Station has found from a large number of published whole milk analyses which he has examined that the average percentages of fat, casein, albumin, and milk sugar in whole milk are 3.5, 3.0, .53, and 4.8 respectively. A skim milk containing these percentages would test 3.1% casein, .55% albumin, and 5.0% sugar. This result agrees more closely with that found by Richmond, and for that reason Richmond's (5) average composition of skim milk was used in determining the average composition of condensed skim milk.

All the condensed milk used was standardized to 27 percent total solids. This gives a condensation factor of -

$$\frac{27 \text{ (total solids of the condensed milk)}}{9.52 \text{ (total solids of skim milk)}} \quad \text{or } 2.84$$

Using this condensation factor and the average composition of skim milk as given by Richmond, (5) the following average composition of condensed skim

milk was determined:

Fat	.34%
Milk sugar . .	13.86
Casein	9.14
Albumin	1.19
Ash	2.22

Use of Condensed Milk in Ice Cream Making

Condensed milk is used in ice cream making as a source of milk solids not fat. Since a considerable portion of the excess water has been removed, it is possible to combine condensed milk, cream, sugar and gelatin in such proportions that the resulting mixture will have the desired percentages of butter fat, milk solids not fat, sucrose and gelatin. Without the use of a milk product from which a large part of the water had been removed, it would be impossible to obtain an ice cream mix sufficiently high in milk solids not fat to insure a desirable body in the finished product.

In most cases the plain bulk condensed milk used in ice cream making has been superheated. This process consists in heating the condensed milk to a temperature ranging from 180° to 190° F. by the introduction of live steam before the milk is drawn from the vacuum pan, but after it has been evaporated to the desired consistency. Since the superheating causes the condensed milk to thicken, the resulting product is thought to be more desirable for ice cream making, the current belief being that it improves the body of the ice cream. Lack of definite information on that point was the incentive for this investigation.

DEFINITIONS

The following definitions of terms peculiar to the dairy manufacturing industry are given to avoid any possible confusion that might arise in the mind of the reader who is unfamiliar with these technical words.

1. Superheated and unsuperheated plain condensed bulk skim milk. These two terms are defined in the introduction, page 1. Whenever reference is made to them in the following discussion the terms Superheated and Unsuperheated Condensed Milk will be used.

2. Milk solids not fat include the milk sugar, casein, albumin and mineral content of the milk products used.

3. Over-run. This term refers to the increase in volume of the ice cream over the volume of the unfrozen mix resulting from the freezing process.

4. Texture. By texture is meant the size, shape and arrangement of the particles or the structure of the ice cream. The smoothness of an ice cream is an index to its texture. An ideal texture is one in which the particles are small, uniform in size and compactly arranged.

5. Resistance. Resistance refers to the ability of the frozen product to remain unmelted when placed in the mouth. This characteristic of ice cream depends upon the number and compactness of the particles. Neither an ice cream that melts quickly like snow, nor one that is so resistant that it is gummy, is desirable. The proper degree of resistance is a relative term, depending a great deal upon the individual, and cannot be defined in such a way as to be accepted by all. However, with a little practice the judge can easily determine whether or not the ice cream has too much or not enough resistance, and any product that may come in between these two extremes can safely be considered as having good resistance.

6. Body. The body of the ice cream refers to the total organized

substance or the mass as a whole. It is dependent upon the texture and resistance of the ice cream. There is a tendency for some authors to confuse this term with texture, whereas texture,together with resistance, is only contributory to the condition of the body. An ice cream body is said to be fluffy, light, good, heavy, or soggy, depending upon the size, shape, and arrangement of the particles and the amount of resistance they offer when the ice cream is eaten.

7. Flavor. By flavor is meant the taste of the ice cream resulting from the kind and amounts of milk products used. For example, an ice cream containing a large amount of milk solids not fat is very likely to acquire a milk sugar (lactose) flavor, especially if kept in storage for a very long period of time. Also, the use of too much condensed milk often results in a condensed milk flavor.

8. Sandiness. By sandiness is meant the condition that exists in ice cream when the milk sugar has crystallized. There are various factors contributing to this condition, such as the percentage of total solids, time held in storage, temperature at which held, etc.

9. Heat resistance. Heat resistance is a term used to describe the ability of ice cream to stand up at a temperature above 0° C.

THE OBJECT OF THE INVESTIGATION

The purpose of this investigation was to make a comparative study of superheated and unsuperheated condensed milk with particular reference to their use in ice cream making. An attempt was made to obtain information relative to the following points:

1. The effect of superheating upon the physical state of the milk proteins.

2. The effect of the use of superheated and unsuperheated condensed milk upon each of the following:

    a. The viscosity of the ice cream mix

    b. The finished product:

        (1) Over-run

        (2) Body

        (3) Texture

        (4) Resistance

        (5) Flavor

        (6) Heat resistance

It was with a view to solving these problems that the plan of the investigation was made.

PLAN OF WORK

Method of Preparing the Condensed Milk

Ordinary separator skimmed milk was used in the manufacture of the condensed milk. The milk was first placed in a large open vat, commonly called the forewarmer, having a capacity of 200-220 gallons, and heated to about 150°F. by the introduction of live steam. It was then drawn into a 3-foot vacuum pan of the C. E. Rogers type, where the excess water was removed by boiling at a

temperature around 130° F. with about a 24-inch vacuum. Heat was supplied by means of a steam coil and jacket and the necessary vacuum was obtained by means of a small steam pump.

After the milk had been concentrated to about 12.5 Baume reading at 130° F., fifteen or twenty gallons were drawn from the pan to be used for comparative study with the superheated condensed. The remainder was then superheated by forcing in live steam until a temperature of 185° - 190° F. was reached. It was held at that temperature until it had thickened to the desired consistency. The amount of time required for the superheating varied from five to fifteen minutes. The milk was then cooled by maintaining a partial vacuum in the condenser. As soon as the temperature dropped to about 130° F. the milk was drawn into 10-gallon milk cans, and the temperature was further reduced by placing the cans in a large tank and surrounding them with running cold water.

The total solids content of both the superheated and the unsuperheated condensed milk was then determined, and enough water was added to standardize each to 27 percent.

Method of Determining the Effect of Superheating upon the Milk Proteins

Samples of both the superheated and unsuperheated condensed milk, after being diluted with about twice their volume of water, were filtered by suction through porous clay filters of the Berkefeld type. The filtrate was then tested for casein and albumin.

Method of Preparing the Mixes

The different batches were mixed in 10-gallon milk cans. The cream, skim milk when used, and condensed milk were placed in the cans before the sugar in order to prevent any undissolved portions of sucrose from adhering to the bottom of the can. The gelatin solution, consisting of 4 ounces of gelatin

to 2 pounds of water for batches 1 through 22 and 100 through 800, and 4 ounces of gelatin to 2 1/4 pounds of water for batches 9 through 12 and 900 through 1200, was placed in a 4-gallon can and heated to a temperature of about 160° F. by submerging the can in a hot water bath. This solution was then carefully added to the mix in a fine stream, stirring constantly to prevent the gelatin from gumming. The vanilla was not added until just before freezing.

With the exception of the first eight batches (which were half the size of the others) all the mixes made had a total weight of approximately fifty pounds, which was sufficient to make eight to ten gallons of ice cream. Forty percent cream, skim milk, twenty-seven percent bulk condensed skim milk, sugar, gelatin, water and vanilla extract were the only ingredients used. The percentages of fat and solids not fat varied in the different mixes, as shown in the table, but the amount of sugar, flavoring and gelatin solution used was constant in each batch. The weighing was done on a 10-pound spring scale graduated to ounces.

Ordinarily from eight to sixteen different batches were run at one time, half of which were made with superheated and half with unsuperheated condensed milk. With the exception of the condensed milk, the same ingredients were used in all the mixes made at the same time. This, in addition to the fact that the same freezer was used for all and that the temperature of the brine remained fairly constant during one day's freezing, furnished a just basis for a comparative study of the use of superheated and unsuperheated condensed milk in ice cream making.

Method of Standardizing the Mixes

Since the gelatin, flavoring and sugar content of the ice cream did not enter into the problem, it was decided to use a constant proportion of these ingredients in preparing the mixes. Four ounces of gelatin, 120 cubic centi-

meters of vanilla and 6 pounds of sugar were used in each batch. Various proportions and combinations of fat and milk solids not fat were used in order that the data secured would not be too restrictive in their source. The following method was used to determine the approximate amounts of the different milk products needed.

All the batches were figured on a 50-pound basis. In each case the composition of the desired mix was known. Since the percentage of fat and total solidswere to be the only variables, the same amounts of the other ingredients were used in each batch as follows: Six pounds of sugar, 4 ounces of gelatin, together with 2 pounds of water in batches 1 through 22 and 100 through 800, and 2 1/4 pounds of water in batches 9 through 12 and 900 through 1200; and 120 cubic centimeters of vanilla. There remained to be found the amounts of cream (40% butterfat, 5.55% S. N. F.), condensed milk (27% total solids), and skim milk (9% total solids), that would be needed. These amounts were determined in the following manner.

1. From the composition of the desired mix the following amounts were determined:

    a. The required number of pounds of fat and solids not fat.

    b. The number of pounds of cream necessary to give the desired percentage of butterfat.

    c. The number of pounds of solids not fat in the cream, assuming the percent of solids not fat in forty percent cream to be 5.55 (8).

    d. The number of pounds of twenty-seven percent condensed milk (assuming no fat to be present) needed to supply the lacking milk solids not fat.

2. The weight of the condensed milk was then added to the weights of

the sugar, cream and gelatin solution, and the total subtracted from 50, the result being the amount of water that would have to be added to standardize the mix to the desired composition.

3. The amount of condensed milk and skim milk equal in composition and weight to the pounds of condensed milk (determined in "d") and the weight of the water (determined in step No. 2) was then determined by dividing the weight of the water by 2 and subtracting the result from the weight of the condensed milk found in "d" to find the weight of the condensed milk, and by multiplying by 3 to find the weight of the skim milk.

It will be noted that no consideration was given to the weight of the flavoring material, the slight amount of butterfat that is contained in skim milk and condensed milk, to the fact that ordinarily skim milk contains a little more than 9 percent total solids, and finally that the total weight of the batch was not exactly 50 pounds. However, the method used was rapid and gave very close to the desired composition and was adopted for that reason. The exact composition of the different batches, together with the ingredients used, is given in Table 1. In determining the percentage compositions in this table proper consideration was given to the above factors.

Example of the Method of Standardizing

Batch No. 1 with a composition of 8 percent gat, 10 percent solids not fat and 30.5 percent total solids, was standardized as follows:

Given: sugar, 6 lbs.

gelatin, .25 lb.

water, 2 lbs.

total weight of mix, 50 lbs.

To find: the amounts of cream, condensed milk, and skim milk needed.

1. Determination of the following amounts:

a. Pounds of fat needed = 50 x .08 = 4

Pounds of milk solids not fat needed = 50 x .1 = 5

b. Pounds of cream needed = $\frac{4}{40}$ x 100 = 10

c. Pounds of solids not fat in cream = 10 x .0555 = .555

d. Pounds of twenty-seven percent condensed milk necessary to supply the lacking milk solids not fat = $\frac{5 - .555}{27}$ x 100 = 16.5

2. Pounds of mixture short = 50 - (10 + 6 + 2.25 + 16.5) = 15.25

3. Pounds of condensed milk and skim milk equal to 16.5 pounds of condensed milk and 15.25 pounds of water are equal to $\frac{15.25}{2}$ = 7.63

16.5 - 7.63 = 8.87 (pounds of condensed milk)

7.63 x 3 = 22.89 (pounds of skim milk)

The following table gives the composition of the different mixes used.

Table 1

Composition of the Mixes

Batch No.	% Fat	% M.S.N.F.	% Sugar	% Gelatin	% T. S.	Lbs. 40% Cream	Lbs. Skim Milk	Lbs. 27% Cond. Milk	Lbs. Water	Total Weight
1 & 100	8.07	10.1	11.93	.5	30.5	10	22.9	8.9	2	50.3
2 & 200	8.11	13.92	11.93	.5	34.37	10	11.8	20	2	50.3
3 & 300	8.29	17.85	12.1	.5	38.65	10		31.1	2	49.6
4 & 400	10.08	10.04	11.98	.5	32.51	12.5	19.8	9.3	2	50.1
5 & 500	10.1	13.82	11.93	.5	36.26	12.5	9	20.3	2	50.3
6 & 600	12.03	10.02	11.93	.5	34.39	15	17	9.8	2	50.3
7 & 700	12.09	13.82	11.93	.5	38.25	15	5.92	20.9	2	50.3
8 & 800	14.02	9.92	11.93	.5	36.28	17.5	14.2	10.1	2	50.3
9 & 900	8.1	12	11.94	.5	32.65	10	17	14.5	2.25	50.25
10 &1000	10.09	11.96	11.94	.5	34.41	12.5	14	15	2.25	50.25
11 &1100	12.06	11.92	11.94	.5	36.34	15	11	15.5	2.25	50.25
12 &1200	14.05	11.92	11.94	.5	38.33	17.5	8	16	2.25	50.25

Method of Determining Viscosity

An ordinary 17.6 cubic centimeters milk pipette was used in determining the relative viscosity of the ice cream mixes and of the condensed milk. Two different pipettes were used. Due to its extreme viscosity, it was necessary to use a pipette with a comparatively large opening to measure the viscosity of the superheated condensed milk. For the unsuperheated condensed milk and the ice cream mixes a pipette with a smaller opening at the discharge end was satisfactory.

In order that all the readings might be reduced to the same base, the time of discharge of the substance expressed in seconds was in each case divided by the time of discharge of distilled water at the same temperature. The result was termed the relative viscosity.

The liquid to be measured was first tempered to 20° C. It was then drawn into the pipette, which was marked at the top and bottom of the enlarged portion. The time required for the top of the column to pass from the upper to the lower of these graduations was then determined with a stop watch. While it was emptying, the pipette was held in a vertical position in a ring stand. It was thoroughly cleaned and dried between operations by means of hot water, alcohol and ether. The temperature of the room was kept as near 20° C. as possible.

Since it was found that duplicate runs resulted in very close checks, single runs were used for mixes 1 through 8 and 100 through 800 in order to facilitate matters as it was desirable to measure the viscosity the same day the batches were frozen. Two runs were made on batches 9 through 12 and 900 through 1200, however, and the averages of these were used in determining viscosity.

Method of Freezing

The freezing of ice cream is accomplished by agitating the mix in a

closed container which is surrounded by some such cooling medium as a mixture of ice and salt or an artificially cooled brine solution.

A chain driven twelve-quart horizontal brine freezer was used in this experiment. A dasher revolving at a speed of 150 revolutions per minute kept the mix in motion while it was being frozen by artificially cooled brine, which was forced by a steam pump through small coils placed in a jacket surrounding the agitated mix. It is necessary to keep the mix in motion in order that it may freeze uniformly and in order to incorporate a certain amount of air, which is necessary to prevent the finished product from being icy and soggy.

The mixes were usually aged for twenty-four hours before being frozen. An attempt was made to have the temperature of the mix not higher than 45° F. at the time it was placed in the freezer.

In the freezing process the brine was allowed to circulate through the freezer until the ice cream had been cooled to a temperature of 26° - 27° F. This required from five to seven minutes, depending upon the composition of the mix and the temperature of the brine. The brine was then shut off and the ice cream allowed to whip until it was ready to be drawn. This point was reached when the ice cream had a consistency similar to that of ordinary hot corn meal mush and required from five to seven minutes after the brine was shut off. In freezing batches 9 through 12 and 900 through 1200, the ice cream was allowed to whip until the maximum amount of air, as determined by the Mojonnier over-run tester, had been obtained. Batches 1 through 8 and 100 through 800 were drawn when the appearance of the ice cream warranted it. Both methods are used in commercial plants.

The freezer was thoroughly rinsed with water after each batch was drawn in order that the composition of the following mix might not be altered in any way. Data relative to the freezing of the ice cream are recorded in Table 2.

Table 2. Data Relative to the Freezing of the Ice Cream

Batch No.		Temp. of Mix	Temp. of Brine	Time to Freeze	Batch No.		Temp. of Mix	Temp. of Brine	Time to Freeze
	a	43° F.	5° F.	8 min.		a	43° F.		
1	b	35	16	14	100	b	45	15° F.	15 min.
	c	42	12	13		c	43	12	13
	a	43	4	7		a	43		7
2	b	44	15	17	200	b	43	14	15
	c	43	12	12		c	44	12	15
	a	43	3	10		a	43		8
3	b	45	14	25	300	b	43	13	15
	c	42	12	16		c	40	12	18
	a	45	4	4		a	43		6
4	b	46	0	11	400	b	42	10	12
	c	42	12	14		c	42	13	12
	a	44	7	8		a	41	10	9
5	b	48	2	11	500	b	43	9.5	12
	c	54	6	22		c	56	6	17
	a	43		9		a	43		6
6	b	48	4	12	600	b	45	9	12
	c	54	6	9		c	52	6	14
	a	43		14		a	43		8
7	b	43	2	16	700	b		3	11
	c	52	7			c	54	6	10
	a	42	0	8		a			6
8	b		10	17	800	b		2	10
	c	54	7	18		c		-4	10
	a	50	0	10		a	45	-2	11
	b	48	10	20		b	45	7	15
9	c	60	-2	11	900	c	50	2	10
	d	46	8	14		d	44	8	14
	a	50	2	14		a	50	-2	11
	b	45	9	12		b	46	6	13
10	c	56	1	12	1000	c	46	2	14
	d	47	8	14		d	47	8	14
	a	49	3	13		a	47	0	11
	b	47	12	14		b	44	9	14
11	c	52	1	12	1100	c	48	8	14
	d	48	8	14		d	43	8	14
	a	52	6	10		a	48	-2	11
	b	43	7	14		b	40	2	10
12	c	50	2	12	1200	c	52	9	15
	d	47	8	14		d	46	8	14

Batches 1 through 12 contained superheated condensed milk.
Batches 100 through 1200 contained unsuperheated condensed milk.

Method of Determining the Over-Run

The over-run on batches 1 through 8 and 100 through 800 was determined in the following manner. A one-half pint Seal-Right paper carton was weighed and then filled with the unfrozen mix and weighed again. It was next filled with the frozen ice cream, which in turn was weighed. The percentage of air that had been incorporated in the ice cream, or the over-run, was then determined by subtracting the net weight of the ice cream from the net weight of the mix, dividing the difference by the net weight of the ice cream and multiplying by 100. For example:

11 oz.- weight of carton filled with mix

1 oz. - weight of carton

10 oz. - net weight of unfrozen mix

7 oz. - weight of carton filled with ice cream

1 oz. - weight of carton

6 oz. - net weight of ice cream

$$\frac{10 - 6}{6} \times 100 = 66.6\% = \text{over-run}$$

The over-run on batches 9 through 22 and 900 through 1200 was obtained with the Mojonnier over-run tester. This machine consists of a graduated scale dial, upon which the percentage of over-run can be read directly, and an adjustable metal cup, in which the mix and ice cream are weighed. The cup is so adjusted by a screw bottom that when exactly filled with the unfrozen mix it balances the dial indicator at zero. After the cup has been properly adjusted, it is locked and is then ready for use. The ice cream is drawn directly from the freezer into the cup and leveled off with a broad knife. It is then placed on the scale and the dial indicator will read directly the percent of over-run, there being a fixed relation between the capacity, the weight of the cup, and the markings on the scale. The cup must be adjusted for each different batch.

Taking the Samples

In order that the quality of the finished product might be determined, three samples were taken from each batch in small one-third pint cartons to be judged later. These samples were always taken from the top of the first can drawn, which gave a fair representation of the whole batch.

Storing the Ice Cream Samples

The samples were placed in a hardening room, which was kept at a temperature ranging from -11° F. to -4° F. The variations in temperature from day to day at 3 P. M. for one month, October 24 to November 24, were as follows:

	Degrees		Degrees
October 24	-5	November 7	+1
25	+2	8	+1
26	-7	9	-7
27	-3	11	+1
29	-4	12	-5
30	+2	13	+5
31	-2	14	+2
November 1	-8	15	-5
2	-9	17	+4
3	-5	19	-6
4	-11	22	+3
5	-11	23	0
6	0	24	-5

Although there was some variation from day to day, the temperature never rose high enough to affect the quality of the ice cream.

Judging the Ice Cream

The samples were removed from the hardening room at different intervals (usually about seven days) and judged. This variation in time served the double purpose of showing the effect of storage upon the produce and of checking up on any discrepancy that may have existed in the judge's opinion regarding the ice cream. It is quite possible that when several samples of varying composition are to be scored the order in which the samples are taken may have some influence upon the judge's opinion of the relative merits of each. For instance, an ice cream containing 28 percent total solids preceding one having 35 percent total solids would have a tendency to make the 35 percent ice cream seem to be a more desirable product than if a 34 percent product had been scored first. By varying the arrangement of samples and by judging samples of the same ice cream at different times, the danger from the above tendency was reduced to a minimum.

The ice cream was judged by Professors H. A. Ruehe, O. R. Overman, and Mr. A. S. Ambrose of the Department of Dairy Husbandry, together with the author. The recorded criticisms are the summarized conclusions of this group of judges.

Method of Determining Heat Resistance

In judging some of the earlier samples it was noted that the ice cream made with unsuperheated condensed milk had less resistance to the tongue than that made with superheated condensed milk. For this reason it was decided to determine whether or not there was any difference in the ability of ice cream, differing only in the use of superheated and unsuperheated condensed milk, to withstand the influence of heat. This was accomplished by subjecting samples of comparative batches of ice cream to the same heat conditions and measuring the amount that melted and dropped off in a given time. Each batch was

represented by triplicate samples.

For this purpose one-half pint and pint paper cartons were used. Since the amount of air incorporated might have some effect upon the rate of melting of the ice cream, samples of the same over-run (as determined by the Mojonnier over-run tester) were used in each comparison.

The test was conducted in the following manner: The samples to be run were removed from the hardening room to the butter storage room, which is maintained at a temperature of 30° F. - 35° F. Here they were removed from the paper cartons by dipping them in hot water, which permitted the carton to be removed without difficulty. The samples were handled by means of a small can sealing wire which extended through the center of the ice cream and was prevented from pulling through by means of a small piece of cardboard upon which the ice cream rested.

After all the samples were prepared as described above, they were returned to the hardening room, where they were kept for a minimum of three hours so as to be thoroughly frozen at the beginning of the experiment. The samples were removed from the hardening room two and three at a time, so that comparative mixes could be weighed at practically the same time. They were then subjected to heat in a closed room where the temperature remained constant.

The samples were placed on small glass jars, which were in turn placed upon trays to catch the ice cream which melted. The weight of each sample was recorded at the start and at one to two hour intervals. In this way the amount and percentage melted could be determined.

EXPERIMENTAL RESULTS

Effect of Superheating upon the Milk Proteins

The effect of superheating upon the relative viscosity of the condensed milk is shown by the following table. In the second column is given the viscosity of the condensed milk before it was superheated, while in the third column is given the viscosity of the same condensed milk after it had been superheated. In all cases the total solids content was standardized to 27 percent.

Sample No.	Before Superheating	After Superheating
1	4.2	93.7
2	2.8	14.2
3	3.4	176.1
4	3.2	241.4
5	2.0	114.0
6	1.7	85.0
7	1.8	95.5
8	2.5	491.8

The extremely viscous condition of the condensed milk that exists after the superheating process has been completed is commonly referred to as the liver, curd, or coagulum. In a way these terms suggest a possible explanation of what happens when condensed milk is superheated, but a more definite explanation is lacking.

From a study of the properties of the butterfat, milk sugar and ash content of milk it is thought that heating these substances to a temperature of 190° F. would not be responsible for the increased viscosity of the condensed milk. If this is true, it necessarily follows, therefore, that the increased viscosity of the condensed milk brought about by superheating is due to a change in the physical form of the milk proteins.

There is some difference of opinion among authorities regarding the number of proteins that are to be found in milk, but it is commonly agreed that there exist comparatively large amounts of casein and albumin, together with

traces of globulin, fibrin, and an alcohol soluble protein. Since casein and albumin are the proteins present in largest amounts, it might be expected that their study would reveal some information relative to the effect of superheating.

Casein is the protein present in milk in the largest proportion, the average percentage in skim milk, as given by Richmond (5), being 3.22 percent. This protein exists in milk in the form of submicrons or very small particles which can be seen with a high powered lens, using the dark field and strong natural or artificial light. The casein occurs in milk in suspension and can be separated out by the use of unglazed porcelain filters.

Casein is insoluble in water and very dilute acids but is soluble in strong acids and caustic alkali solutions. Acids do not cause complete separation of the casein unless the temperature is raised to the boiling point. Heating above 266° F. (9) will cause casein to coagulate.

Next to casein, albumin is the most important protein in milk. According to Richmond (5), the average percentage of albumin present in skim milk is .42. This author also states that albumin is present in milk in the form of a colloidal solution and is coagulated by raising the temperature of its solution to 158° F.

In the light of the above statements, it is to be expected that the increased viscosity of superheated condensed milk is due to the coagulation of the albumin present. That a change in the physical state of the albumin is brought about by the superheating process was proven by filtering both superheated and unsuperheated condensed milk through porous dry filters and analyzing the filtrate for both casein and albumin.

The milk was first thoroughly mixed with twice its volume of water and then placed in porous dry filters of the Berkefeld type. A colorless filtrate was secured by applying suction to the clay plate.

In the case of the superheated condensed milk this filtrate contained no protein. The filtrate of the unsuperheated condensed milk, however, gave very pronounced reaction with the protein tests used. The following tests for protein were used:

1. Xanthoprotein Reaction
2. Millon's Reaction
3. Buiret Reaction

The filtrate of the unsuperheated condensed milk was further analyzed for casein and albumin. About fifty cubic centimeters of the filtrate was first made neutral with dilute sodium hydroxide. Dilute hydrochloric acid was then added a few drops at a time until 1.5 cubic centimeters had been added. The filtrate was allowed to stand a few minutes, but no precipitate was formed, indicating that no casein was present. Another portion of the filtrate was then boiled until a floculent precipitate was obtained, indicating the presence of albumin.

Since 27 percent condensed skim milk contains only about 1.19 percent albumin, it is hard to conceive how such a small amount of albumin when coagulated by heat could produce so high a degree of viscosity that occurs in superheated condensed milk. This may be explained by the fact that the superheating changes the albumin from a colloidal to a finely divided precipitated form. In this state it is possible that the albumin particles not only adsorb each other but the casein as well, producing an effect not unlike an emulsion, the albumin in this case being the dispersed phase.

The Effect of the Use of Superheated and Unsuperheated Condensed Milk upon the Ice Cream

Comparative criticisms of ice cream containing superheated and that containing unsuperheated condensed milk are given in the following table. This tabulation includes the joint criticisms of four judges upon 80 different batches

Table

Criticisms
and 1

Sandy

Old

Condense

Lactose

Heavy

Good

Light

Fluffy

Too much

Good

Lacking

Very smooth

Smooth

Coarse

Very coarse

Age (Days)

Percent M.S.N.F.

Percent Fat

Batch No.

Batch No.	Fat %	Total Solids %	Age (Days)	Texture: Very coarse	Texture: Coarse	Texture: Smooth	Texture: Very smooth	Resistance: Lacking	Resistance: Good	Resistance: Too much	Body: Fluffy	Body: Light	Body: Good	Body: Heavy	Flavor: Lacking	Flavor: Good	Flavor: Old	Flavor: Sandy	REMARKS
1a	6	10	6			x			x				x						
1a	6	10	11		x				x				x						
1a	6	10	20		x				x				x						
1b	6	10	9			x			x				x						Breaks down rate by.
1b	6	10	15		x				x				x						
1b	6	10	22		x				x				x			x			
1c	6	10	1		x				x				x						
1c	6	10	13		x				x				x						
1c	6	10	23		x				x				x						
100a	6	10	6	x					x		x								
100a	6	10	13	x					x		x								
100a	6	10	20	x					x		x								
100b	6	10	9	x					x		x								
100b	6	10	15		x				x		x								
100b	6	10	22		x				x		x								
100c	6	10	1		x				x		x								
100c	6	10	13		x				x		x								
100c	6	10	23		x				x		x								
2a	6	14	6			x				x				x					Good commercial ice cream
2a	6	14	13			x				x				x					
2a	6	14	20			x				x				x					
2b	6	14	9			x				x				x					
2b	6	14	15				x				x					x		x	
2b	6	14	22			x				x				x	x	x		x	
2c	6	14	3		x					x			x						
2c	6	14	13		x						x			x					
2c	6	14	23			x				x				x				x	
200a	6	14	9			x			x				x						
200a	6	14	13		x				x				x						
200a	6	14	20		x				x				x					x	
200b	6	14	9			x				x				x					
200b	6	14	15			x				x				x		x			
200b	6	14	22			x				x				x		x			
200c	6	14	3		x					x			x						
200c	6	14	13		x					x			x						
200c	6	14	23		x					x			x					x	
3a	6	18	6			X		X						X					
3a	6	18	13			X		X						X				x	
3a	6	18	20			X		X						X				x	
3b	6	18	9			X			x					X		x			
3b	6	18	15			X								X		X		x	
3b	6	18	22			X			x					X	x	X		x	
3b	6	18	1			X			x					X					
3c	6	18	13			X			x					X				x	
3c	6	18	23			X			x					X				x	
300a	6	18	6		X				x				x					x	Less resistance than No. 3a
300a	6	18	13		X				x				x					x	" " " " " "
300a	6	18	20		X				x				x					x	" " " " " "
300b	6	18	9		X				x				x					x	
300b	6	18	15		x				x				x			x			
300b	6	18	22		X				x				x			x			Better flavor than No. 3b
300c	6	18	3			x			x				x						
300c	6	18	13			x			X				x		x			x	
300c	6	18	23			x			X				x			x		x	
4a	10	10	6					x				x							
4a	10	10	13		x				x				x						
4a	10	10	20					x					x						
4b	10	10	8						x		x								
4b	10	10	15		x				x		x					x			
4b	10	10	22		x				x		x					x			
4b	10	10	1		x				x				x						
4c	10	10	13		x				x				x						
4c	10	10	23		x				x				x						
400a	10	10	6						X				X						
400a	10	10	13						X				X						
400a	10	10	20		x				X				x						
400b	10	10	8		x								x						
400b	10	10	15		x				X				x						
400b	10	10	22		x				x				x						
400c	10	10	3		x				x				x						
400c	10	10	13		x				x				x		x				
400c	10	10	23		X				x				x						
5a	10	14	6			x							X		x				Ideal body
5a	10	14	13			x							X			x			
5a	10	14	20			x							X			x			
5b	10	14	8			x			x				x		x	x			
5b	10	14	15		x				x				x			x			
5b	10	14	22		x				x				x		x	x			
5c	10	14	3			X			X				X						
5c	10	14	17		x				x				x		x			x	
5c	10	14	28		x				X				x		x	x		X	
500a	10	14	6	x					x				x					x	
500a	10	14	13	x					x				x					x	
500a	10	14	20	x					x				x					x	
500b	10	14	8		x				x				x						
500b	10	14	15		x				x				x						
500b	10	14	22		x				x				x						
500c	10	14	3		x				x				x						
500c	10	14	17	x					x				x					x	
500c	10	14	28		x				x				x					X	
6a	12	10	6		X				X				X						
6a	12	10	13		X				X				X						
6a	12	10	20		x				X				X						
6b	12	10	8		x				x				x						
6b	12	10	15		x				x				x						
6b	12	10	22		x				x				x						
6c	12	10	3		x				x				x						
6c	12	10	17		x				x				x						
6c	12	10	28		x				x				x						
600a	12	10	6						X			x							
600a	12	10	13						X				X						
600a	12	10	20						X				X						
600b	12	10	8		x				x				X						
600b	12	10	15		x				x				X						Poorer body than No. 6b
600b	12	10	22		x				x				x						Coarser than No. 6c.
600c	12	10	3		x				x				x						
600c	12	10	17		x				x				x						Very good flavor
600c	12	10	28		x				x				x						
7a	12	14	6			x							x					x	
7a	12	14	13				x											x	
7a	12	14	20				x		x									x	
7b	12	14	7				x		X					x					
7b	12	14	14				X			x					x				
7b	12	14	24				X			x					x			x	
7c	12	14	3			x				x				x					
7c	12	14	17			x				x				x				x	
7c	12	14	28			x				x				x				x	
700a	12	14	6				x							x				x	
700a	12	14	13				x							x				x	
700a	12	14	20				x			x				x					Not as smooth as No. 7b
700b	12	14	7				x			x				x					Not as resistant as No. 7b
700b	12	14	14				x			x					x			x	Better flavor than No. 7b
700b	12	14	24				x			x					x	x			
700c	12	14	3				x		x					x					Better flavor than No. 7c
700c	12	14	17			x			x					x					
700c	12	14	28			x			x					x					
8a	14	10	6		x				x				x						
8a	14	10	13		x				x				x						
8a	14	10	20		x				x				x						
8b	14	10	7		x					x				x					
8b	14	10	14		x					x				x					
8b	14	10	24		x					x				x				x	
8c	14	10	3				x			x				x					
8c	14	10	17		x					x				x					
8c	14	10	28		x					x				x					Has better flavor than 8a
800a	14	10	10		x								x						
800a	14	10	13		x								x						Smoother than No. 8a
800a	14	10	20		x								x						
800b	14	10	7	x						x				x					
800b	14	10	14	x						x				x					
800b	14	10	24		x					x				x					Not as smooth as No. 8c
800c	14	10	3		x					x				x					" " resistant as No. 8c
800c	14	10	17		x					x				x					
800c	14	10	28		x					x				x					

Batches 1 through 5 contained superheated condensed milk.
Batches 100 through 800 contained unsuperheated condensed milk.
The percentages of fat and total solids are approximate; the exact percentages are given in Table 1.

Table 3, Part I
Criticisms on batches 1 through 8
and 100 through 800

Batch No.	Percent Fat	Percent M.S.N.F.	Age (Days)	Texture				Resistance			Body				Flavor				REMARKS
				Very coarse	Coarse	Smooth	Very smooth	Lacking	Good	Too much	Fluffy	Light	Good	Heavy	Lactose	Condense	Old	Sandy	
9a	8	12	2		x			x					x						
9a	8	12	8		x			x					x						
9a	8	12	14		x			x					x						
9b	8	12	2		x			x					x						
9b	8	12	8		x			x					x						
9b	8	12	29		x			x					x				x		Old flavor pronounced
9c	8	12	19		x			x				x							
9c	8	12	32		x			x				x					x		Old flavor pronounced
9c	8	12	47		x			x				x					x		Old flavor pronounced
9d	8	12	2		x			x				x							
9d	8	12	11		x			x				x							
9d	8	12	18		x			x				x					x		
900a	8	12	2		X			X				x							
900a	8	12	8		X			X				x							
900a	8	12	14		X			X				x							
900b	8	12	2		X			X				x							
900b	8	12	8		X			X				x							
900b	8	12	29		X			X				x							
900c	8	12	19		X			X				X							
900c	8	12	32		X			X				X							Better flavor than 9c
900c	8	12	47		X			X				X					x		
900d	8	12	2		X			X				X							
900d	8	12	11		X			X				X							
900d	8	12	18		X			X				X					x		
10a	10	12	2		x				x				x						
10a	10	12	8		x				x				x						
10a	10	12	14		x				x				x						
10b	10	12	2		x				x				x						
10b	10	12	8		x				x				x						
10b	10	12	29		x				x				x				x		
10c	10	12	19			x			x				x						
10c	10	12	32			x			x				x						

Batch No.	Percent Fat	Percent S.N.F.	Age (Days)	Texture: Very coarse	Texture: Coarse	Texture: Smooth	Texture: Very smooth	Resistance: Lacking	Resistance: Good	Resistance: Too much	Body: Fluffy	Body: Light	Body: Good	Body: Heavy	Flavor: Lactose	Flavor: Condense	Flavor: Old	Flavor: Sandy	REMARKS
9a	8	12	2		x			x					x						
9a	8	12	8		x			x					x						
9a	8	12	14		x			x					x						
9b	8	12	2		x			x					x						
9b	8	12	8		x			x					x						
9b	8	12	29		x			x					x				x		Old flavor pronounced
9c	8	12	19		x			x				x							
9c	8	12	32		x			x				x					x		Old flavor pronounced
9c	8	12	47		x			x				x					x		Old flavor pronounced
9d	8	12	2		x			x				x							
9d	8	12	11		x			x				x							
9d	8	12	18		x			x				x					x		
900a	8	12	2		X			X				X							
900a	8	12	8		X			X				X							
900a	8	12	14		X			X				X							
900b	8	12	2		X			X				X							
900b	8	12	8		X			X				X							
900b	8	12	29		X			X				X							
900c	8	12	19		X			X				X							
900c	8	12	32		X			X				X							Better flavor than 9c
900c	8	12	47		X			X				X					x		
900d	8	12	2		X			X				X							
900d	8	12	11		X			X				X							
900d	8	12	18		X			X				X					x		
10a	10	12	2		x				x				x						
10a	10	12	8		x				x				x						
10a	10	12	14		x				x				x						
10b	10	12	2		x				x				x						
10b	10	12	8		x				x				x						
10b	10	12	29		x				x				x				x		
10c	10	12	19			x			x				x						
10c	10	12	32			x			x				x						
10c	10	12	47		x				x				x						
10d	10	12	2			x			x				x						
10d	10	12	11			x			x				x						
10d	10	12	18			x			x				x						
1000a	10	12	2		X			x				x							
1000a	10	12	8		X			x				x							
1000a	10	12	14		X			x				x							
1000b	10	12	2		X			x				x							
1000b	10	12	8		X			x				x							
1000b	10	12	29		X			x				x							
1000c	10	12	19		x			x				x							
1000c	10	12	32		x			x				x							
1000c	10	12	47		x			x				x							
1000d	10	12	2			x			x				x						
1000d	10	12	11		x			x				x							Comparable to 9d
1000d	10	12	18		x			x					x						
11a	12	12	2				x		X				x						
11a	12	12	8				x		X				x						Chalky flavor
11a	12	12	14				x		X				x						
11b	12	12	2				x		X				x						
11b	12	12	8				x		X				x						Chalky flavor
11b	12	12	29				x		X				x						
11c	12	12	19				x		X				x						
11c	12	12	32				x			x			x				x		
11c	12	12	47				x		X				x				x	x	
11d	12	12	2				x		X				x						
11d	12	12	11				x			x			x			X			
11d	12	12	18				x		X				x			X	x		
1100a	12	12	2			x			x				x						
1100a	12	12	8			x			x				x						
1100a	12	12	14			x			x				x						
1100b	12	12	2			x			x				x						
1100b	12	12	8			x			x				x						
1100b	12	12	29			x			x				x						Better flavor than 11b
1100c	12	12	19			x			x				x						
1100c	12	12	32			x			x				x						
1100c	12	12	47			x			x				x						
1100d	12	12	2			x			x				x						Very good flavor
1100d	12	12	11			x			x				x						Comparable to 10d
1100d	12	12	18			x			x				x				x		
12a	14	12	2				X			x				x					
12a	14	12	8				X			x				x					
12a	14	12	14				X			x				x					
12b	14	12	2				X			x				x					
12b	14	12	8				X			x				x					
12b	14	12	29				X			x				x	x				
12c	14	12	19				X		x					x					
12c	14	12	32				X			x				x		X	x	x	
12c	14	12	47				X		x				x			X	x	x	
12d	14	12	2				X			x				x					
12d	14	12	11				X			x				x		X			
12d	14	12	18				X		x				X			X	x		
1200a	14	12	2			X			X				x						
1200a	14	12	8			X			X				x						
1200a	14	12	14			X			X				x						
1200b	14	12	2			X			X				x						
1200b	14	12	8			X			X				x						
1200b	14	12	29			X			X				x						
1200c	14	12	19			X			X				x						
1200c	14	12	32			X			X				x						
1200c	14	12	47			X			X				x						
1200d	14	12	2			X			X				x						
1200d	14	12	11			X			X				x						Comparable to 11d
1200d	14	12	18			X			X				x						

Batches 9 through 12 contained superheated condensed milk.
Batches 900 through 1200 contained unsuperheated condensed milk.
The percentages of fat and total solids are approximate; the exact percentages are given in Table 1.

Table 3, Part II

Criticisms on batches 9 through 12
and 900 through 1200

Sandy

Old

Conuenee

Lactose

Heavy

Good

Light

Fluffy

Too much

Good

Lacking

Very smooth

Smooth

Coarse

Very coarse

Age (Days)

Percent S.N.F.

Percent Fat

Batch No.

10c	10	12	47	x			x			x					
10d	10	12	2		x		x			x					
10d	10	12	11		x		x			x					
10d	10	12	18		x		x			x					
1000a	10	12	2	X			x			x					
1000a	10	12	8	X			x			x					
1000a	10	12	14	X			x			x					
1000b	10	12	2	X			x			x					
1000b	10	12	8	X			x			x					
1000b	10	12	29	X			x			x					
1000c	10	12	19	x			x			x					
1000c	10	12	32	x			x			x					
1000c	10	12	47	x			x			x					
1000d	10	12	2		x		x			x					
1000d	10	12	11	x			x			x					Comparable to 9d
1000d	10	12	18	x			x			x					
11a	12	12	2			x		X			x				
11a	12	12	8			x		X			x				Chalky flavor
11a	12	12	14			x		X			x				
11b	12	12	2			x		X			x				
11b	12	12	8			x		X			x				Chalky flavor
11b	12	12	29			x		X			x				
11c	12	12	19			x		X			x				
11c	12	12	32			x			x		x			x	
11c	12	12	47			x		X			x			x	x
11d	12	12	2			x		X			x				
11d	12	12	11			x			x		x		X		
11d	12	12	18			x		X			x		X	x	
1100a	12	12	2		x		x			x					
1100a	12	12	8		x		x			x					
1100a	12	12	14		x		x			x					
1100b	12	12	2		x		x			x					
1100b	12	12	8		x		x			x					
1100b	12	12	29		x		x			x					Better flavor than 11b
1100c	12	12	19		x		x			x					
1100c	12	12	32		x		x			x					
1100c	12	12	47		x		x			x					
1100d	12	12	2		x		x			x					Very good flavor
1100d	12	12	11		x		x			x					Comparable to 10d
1100d	12	12	18		x		x			x				x	
12a	14	12	2			X			x			x			

of ice cream (representing approximately 900 gallons of ice cream) half of which contained superheated condensed milk and half unsuperheated condensed milk. Each batch was judged at three different intervals of time, making in all 240 criticisms. Twelve different combinations of fat and milk solids not fat are represented. The composition of the different batches is shown on page 11.

Explanation of Table. - Numbers 1 through 12 represent the mixes containing superheated condensed milk, and 100 through 1200 represent the comparative mixes that contain unsuperheated condensed milk. Either a small or a large x is used in indicating the criticism. The large X signifies a greater degree of whatever criticism is made.

It may be seen from the foregoing table that there is considerable difference in the ice cream containing superheated condensed milk and that containing unsuperheated condensed milk.

The data show conclusively that the use of superheated condensed milk causes the ice cream to have a better body and a smoother texture and also increases the amount of resistance. On the other hand, ice cream containing unsuperheated condensed milk is not so likely to develop an old or condensed milk taste upon being held in storage and has a superior flavor even when fresh, due to the fact that the fresh milk flavor of the unsuperheated condensed milk has not been destroyed by heating to a high temperature.

Since superheating causes a change in the physical state of the milk proteins, it might be expected that the use of superheated condensed milk would be a contributory factor to the development of sandiness in the ice cream. However, the data indicate that there is no appreciable amount of difference in the tendency which comparative mixes have to become sandy.

Since the greatest amount of condensed milk was used in those batches having the highest percentage of milk solids not fat, it might be expected that

those batches would show the greatest effect of the use of superheated condensed milk. However, the converse was true, for the greatest difference was in those batches containing a low percentage of milk solids not fat and in which only nine or ten pounds of condensed milk were used. This can be explained from the fact that the addition of a slight amount of solids is more noticeable up to a certain point than it is beyond that point. Consequently, the addition of a few more solid particles to those mixes containing from 30 to 33 percent total solids would seem to have a greater effect upon the texture, resistance and body of the ice cream than the addition of two or three times as many particles to those mixes containing from 35 to 38 percent total solids.

The data also show that it is possible for the use of unsuperheated condensed milk to result in a better ice cream than that made with superheated condensed milk. Referring to batches 3 and 12, it will be noticed that due to the high solids content, neither the body, texture nor resistance of the ice cream is as desirable as that of the comparative batches containing unsuperheated condensed milk. By way of explanation, it may be said that the percentage of total solids in these batches is probably such that the addition of any more solid particles subtracts from, rather than adds to, the merits of the ice cream.

It was the opinion of the judges that in general the use of the superheated condensed milk was equivalent to the addition of about 2 percent solids. For example, it was noted that 1200 d, containing 38 percent total solids, was comparable to 11 d, which contained 36 percent total solids. Also, 1100 d seemed to have about the same texture and resistance as 10 d, which contained 2 percent less total solids.

Effect of the Use of Superheated Condensed Milk upon the Over-Run Obtained

Since ice cream mixes containing superheated condensed milk have a greater viscosity than those containing unsuperheated condensed milk,[1] it is to be expected that the ice cream made from the former will have a higher percentage of over-run than that made from the latter. That such is the case is shown by the comparison of the over-run obtained on 28 batches containing superheated condensed milk and 28 batches containing unsuperheated condensed milk, as given in the following tables.

Tables Showing Difference in Over-run of Ice Cream Made from Superheated and Unsuperheated Condensed Milk

Table 4.

Part 1

Batch No.	1	100	2	200	3	300	4	400
Series B	81.4	73.7	90.9	99.2	80	66.7	77.3	70.5
Series C	90	73	81.8	81.8	86	73.3	90.2	79.3
Average	85.7	73.4	86.3	90.5	83	70	83.8	74.9

Part 2

Batch No.	5	500	6	600	7	700	8	800
Series B	81.8	60.4	86.4	85.7	92.9	83.3	92.3	60.8
Series C	65.2	56.5	82	51	68.2	52.2	63.6	53
Average	73.5	58.5	84.2	68.4	80.6	67.8	78	56.9

Table 5

Batch No.	9	900	10	1000	11	1100	12	1200
Series B	88	75	87	80	87	80	85	85
Series C	78	72	80	70	80	67	88	73
Series D	70	70	76	74	78	68	80	65
Average	78.7	72.3	81	74.7	81.7	71.7	84.3	74.3

[1] See page 26.

Graphs Showing the Difference in Over-run Obtained from Mixes Made with Superheated Condensed Milk and those made with Unsuperheated Condensed Milk

The data used are the averages given in Table No. 4 for Graph A and Table No. 5 for Graph B.

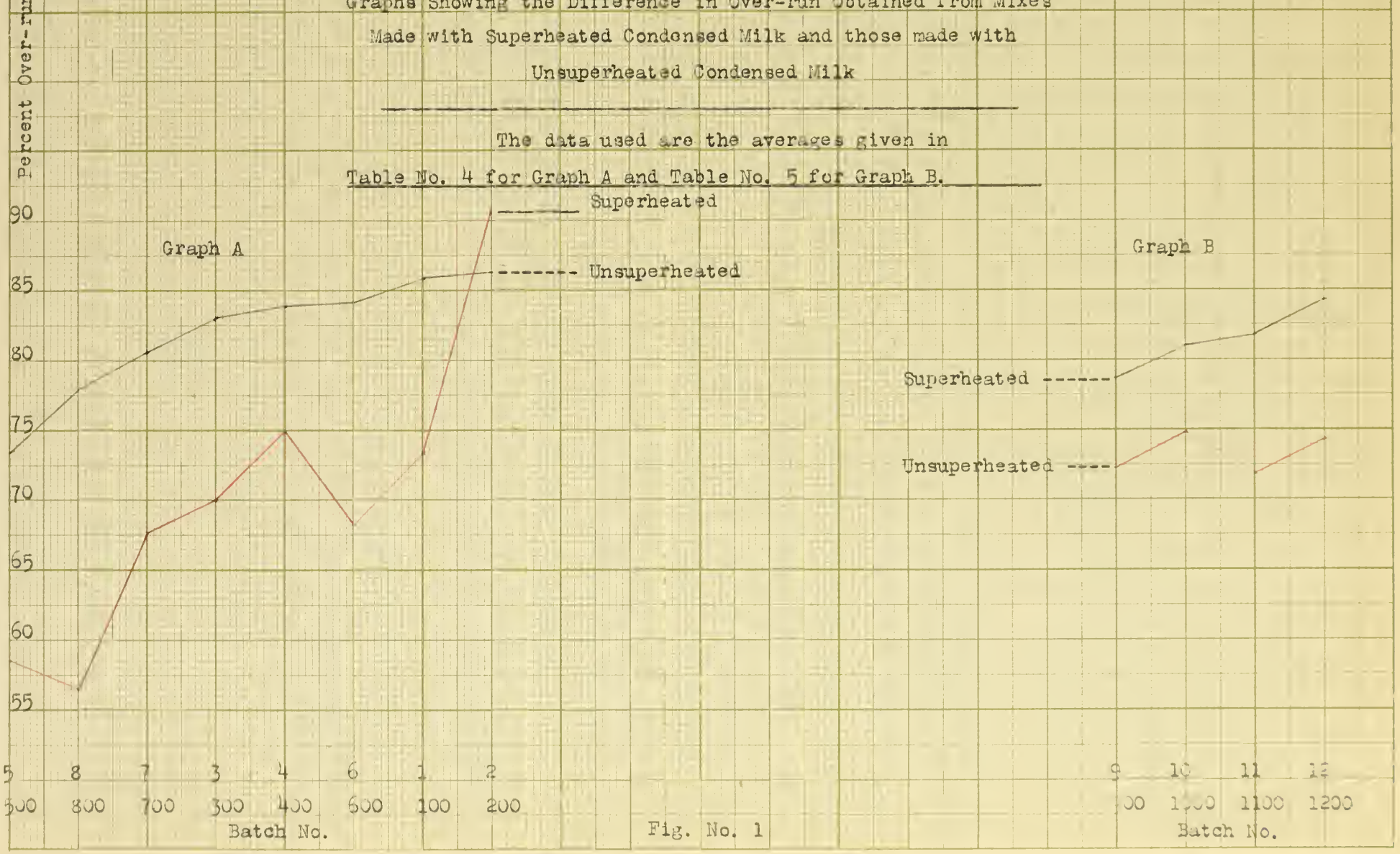


Fig. No. 1

The following graphs of the averages given in the preceding tables show to a somewhat better advantage the difference in over-run obtained.

The ice cream represented in Table 4 was drawn from the freezer when it appeared to have been frozen sufficiently. This is the method commonly used in commercial practice. There are plants, however, where the ice cream is not drawn until a maximum over-run is obtained. This was the method followed in securing the data given in Table 5.

It will be noted that in practically all cases a greater over-run was obtained from those mixes containing superheated condensed milk than from those containing unsuperheated condensed milk. There seemed to be no definite relation between the amounts of condensed milk used and either the amount of over-run obtained or the difference in over-run between comparative batches. This may have been partly due to the fact that the batches were made at different times, resulting in the use of different ingredients. Also, the freezing conditions were not always the same, the brine being colder some days than others. However, in general it may be said that there is a tendency for the use of superheated condensed milk to increase the amount of over-run obtained.

Effect of the Use of Superheated Condensed Milk upon the Viscosity of the Ice Cream Mix

Since superheating results in a marked increase in viscosity of the condensed milk, it is to be expected that ice cream mix containing superheated condensed milk will have a greater viscosity than that in which concentrated skim milk is used. This difference is shown in Table 6.

Table Showing Difference in Viscosity of Ice Cream Mixes Made from Superheated and Unsuperheated Condensed Milk

Table 6

Part 1

Batch No.	1	100	2	200	3	300	4	400
Fat %	8	8	8	8	8	8	10	10
M.S.N.F. %	10	10	14	14	18	18	10	10
Series A	3.9	3.6	16.6	11.4	50.2	10.7	12.5	8
Series B	11.7	6.3	30.5	15	125.8	28.3	11.4	9
Series C	9.5	7.4	20	15.3	78.2	22.5	10.3	7.1
Average	8.4	5.8	22.4	13.9	84.7	20.5	11.4	8

Part 2

Batch No.	5	500	6	600	7	700	8	800
Fat %	10	10	12	12	12	12	14	14
M.S.N.F. %	14	14	10	10	14	14	10	10
Series A	25.8	13.4	8.9	8.9	15.3	12	14.2	9.4
Series B	26.7	15	12	5.8	34.2	19.6	24.8	14
Series C	21.7	13.	10.	9.7	25.1	13.4	13.1	12.1
Average	24.7	13.8	10.3	8.1	24.9	15	17.4	11.8

Batches 1 through 8 contained superheated condensed milk.
Batches 100 through 800 contained unsuperheated condensed milk.

It will be noted that in every case the mix containing the superheated condensed milk had greater viscosity than the corresponding one made from unsuperheated condensed milk. The greatest difference was in batches 3 and 300, where the average increase in viscosity was 313.1 percent. The least difference was in batches 6 and 600, where the average increase was 27.1 percent. By referring to Table 1, page 11, it will be noted that in batch 3, 31.1 pounds of condensed milk were used, while in batch 6, 9.3 pounds were used, which accounts for the great difference in the percentage of increase of viscosity in the two cases.

That the percentage of butterfat present in the mix is also an important factor in determining the viscosity is shown by comparing the average viscosities of batches 1 and 100 with those of batches 4 and 400. In both cases the percentage of milk solids not fat is practically 10, whereas the percentage of fat in batches 1 and 100 is 8 and the percentage of fat in batches 4 and 400 is 10. In those batches containing 8 percent butterfat the average viscosity was 8.4 and 5.8 for the mixes containing superheated and unsuperheated condensed milk respectively, whereas in the batches containing 10 percent butterfat, the average viscosity was 11.4 for the mixes containing superheated condensed milk and 8 for the batches containing unsuperheated condensed milk. The percentage of increase in case of the superheated condensed milk was 35.6 while in the case of the unsuperheated condensed milk it was 37.9.

That the use of superheated condensed milk has a greater influence upon the viscosity than does the butterfat is shown by a comparison of batch 5, which contained 10 percent butterfat and 14 percent milk solids not fat, and batch 8, which contained 14 percent fat and 10 percent milk solids not fat. In the case of the former, 20.3 pounds of superheated condensed milk were used, while in the case of the latter, 10.1 pounds of superheated condensed milk were used. The average viscosity of batch 5 was 24.7, while that of batch 8 was 17.4, or 28.2 percent less.

A comparison of the viscosities of batches varying in percentage of fat but having the same amount of solids not fat is given in the following table.

Table Showing Relation between the Viscosities of Mixes Containing Superheated and Unsuperheated Condensed Milk and the Effect of the Amount of Butterfat Present upon the Viscosity

Table 7

Batch No.	9	900	10	1000	11	1100	12	1200
Fat %	8	8	10	10	12	12	14	14
M.S.N.F. %	12	12	12	12	12	12	12	12
Series A	12	7.9	19.3	8	21.4	12.3	26.7	17.1
Series B	9.7	3.5	17.7	8	18	9.7	24.8	16.8
Series C	6.8	3.6	8.5	4.8	11.3	6	16	7.5
Series D	9.7	3.7	11.8	5.3	13.8	7.2	17	6.7
Average	9.6	4.7	14.3	6.5	16.1	8.8	21.1	12

Batches 9 through 12 contained superheated condensed milk
Batches 900 through 1200 contained unsuperheated condensed milk

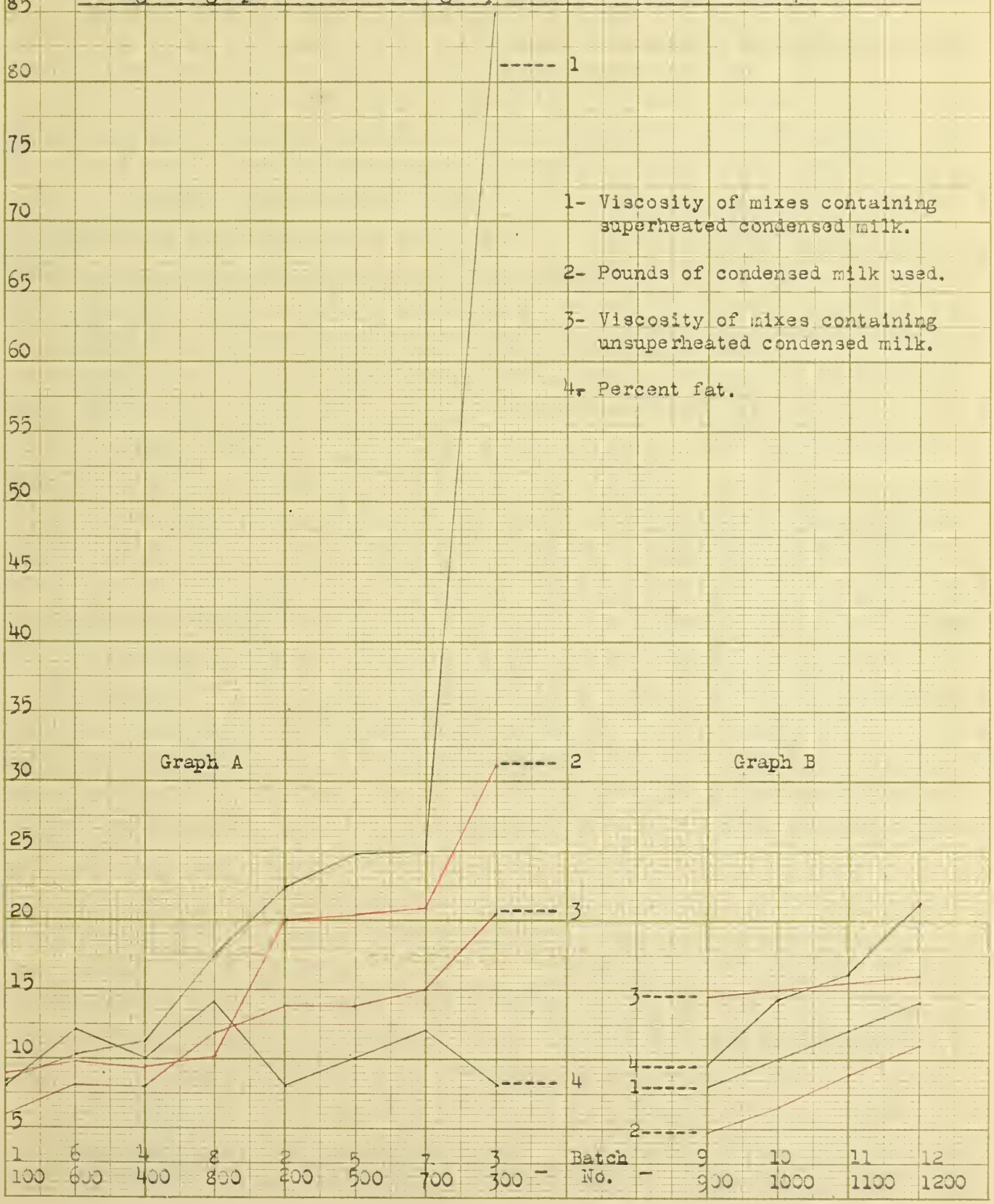
In all cases the mix containing the superheated condensed milk had a greater viscosity than that containing the unsuperheated condensed milk. As in Table 6, the above data also show the tendency of an increase in percentage of fat to increase the viscosity of the mix. This relation between the viscosity of mixes containing superheated and unsuperheated condensed milk, as well as the relation existing between the viscosity of the mixes containing the same percentage of milk solids not fat but different percentages of fat, is shown in Graph B (Fig. 2) of the data presented in Table 7.

The graphs in Fig. 2, in addition to showing the difference in the average viscosities of the batches as given in Tables 6 and 7, also show the relation between the viscosity, the amount of condensed milk used, and the percentage of butterfat in the mix. This relation is well brought out in Graph A.

It will be noted that there is less difference in the viscosity of batches 8, 4, 6, 1 and batches 800, 400, 600, and 100 than in any of the other batches. All of these mixes contained 10 percent milk solids not fat and from

Fig. No. 2

The following graphs show not only the difference in the viscosity of ice cream mixes made from superheated and unsuperheated condensed milk, but also the effect of the percentage of fat in the mix and the amount of condensed milk used upon the viscosity. The viscosity data used in making the graphs are the averages presented in Tables 6 and 7.



8.9 to 10.1 pounds of condensed milk. It will also be noted that the viscosity rises rather rapidly with batches 8 and 800, which can be explained by the fact that those mixes contained 14 percent fat.

Graph A plainly shows the increase in viscosity due to the use of superheated condensed milk, and that as the amount of condensed milk used was increased the viscosity of the mix also increased, the amount of increase being modified somewhat by the percentage of butterfat. However, the greater increase was due to the percentage of milk solids not fat and the amount of condensed milk used. This is shown by the increase in viscosity of batches 5 and 500 and batches 3 and 300 over batches 8 and 800 and 7 and 700 respectively. In both cases the percentage of milk solids was the same; however, those containing the greater percentage of milk solids not fat (which also contained the greater amount of condensed milk) had the greater viscosity.

Graph B also shows how the increase in percentage of fat and the amount of condensed milk used causes an increase in the viscosity of the mix. Since the percentage of milk solids not fat was constant, while the percentage of fat increased with each batch, the increase in viscosity in this case was mostly due to the increased amount of butterfat present, as there was only a slight increase in amount of condensed milk used.

Effect of the Use of Superheated Condensed Milk upon the Heat Resistance of the Ice Cream

The relation existing between the amount of heat resistance offered by ice cream containing superheated condensed milk and that containing unsuperheated condensed milk is shown in the following tables.

Tables Showing Differences in Melting of Ice Cream made from Superheated and Unsuperheated Condensed Milk

Table 8

No.	Weight (grams)				Amount Melted			Percent Melted			Temp.	Over-run
	At Start	After 1 hr.	After 1½ hr	After 2 hr	After 1 hr	After 1½ hr	After 2 hr	After 1 hr	After 1½ hr	After 2 hr		
13 a	153	143	100.5	69	10	52.5	84	6.5	34.3	54.9	24°C.	75%
13 b	159	141	104.5	71	15	54.5	88	9.4	34.3	56.6	"	"
13 c	157	142	100	68	15	57	89	9.5	36.3	56.7	"	"
Av.	156.3	142	101.6	69.3	13.3	54.7	87	8.5	35	56.1		
14 a	156	142.5	99	70	13.5	57	86	8.6	36.5	55.1	24°C.	75%
14 b	153	137	101	69	16	52	84	10.5	34	54.9	"	"
14 c	159	146	105	68	13	54	91	8.2	33.3	57	"	"
Av.	156	141.8	101.7	69	14.2	54.3	87	9.1	34.8	55.7		
15 a	157	148	116	82	9	41	75	5.7	26.1	47.8	24°C.	75%
15 b	162	154	118.5	84	8	43.5	78	4.9	26.8	49	"	"
15 c	155	146	115.5	78	9	39.5	77	5.8	25.5	49.7	"	"
Av.	158	149.3	116.7	81.3	8.7	41.3	76.7	5.5	26.1	48.5		
16 a	250	237		125	13		125	5.2		50	20.5°C.	70%
16 b	253	238		133	15		120	5.9		47.8	"	"
16 c	249	235		121	14		128	5.6		51.4	"	"
Av.	250.7	236.7		126.3	14		124.3	5.6		49.7		
17 a	246	236		144	10		102	4.1		41.7	20.5°C.	70%
17 b	240	231		138	9		102	3.8		42.5	"	"
17 c	238	230		129	8		109	3.4		45.8	"	"
Av.	241.3	232.3		137	9		104.2	3.7		43.3		
18 a	235	235		159.5	0		75.5	0		32.1	20.5°C.	70%
18 b	242	242		168	0		74	0		30.6	"	"
18 c	238	238		173	0		65	0		27.3	"	"
Av.	238.3	238.3		166.8	0		71.5	0		30		

Composition of Mixes in Table 8

No.	Fat %	M.S.N.F. %	Sugar %	Gelatin %	T.S. %	Lbs.40% Cream	Lbs. Skim	Lbs. Cond.	Lbs. Water
13&16 a b c	10	10	12	.5	32.5	12.5	19.8	9.3 x	2
14&17 a b c	10	10	12	.5	32.5	12.5	19.8	9.3 xx	2
15&18 a b c	10	10	12	.5	32.5	12.5	----	15.9xx	15.35

x - unsuperheated xx - superheated

Table 9

No.	Weight (Grams)				Amount Melted			Percent Melted			Temp.	Over-run
	At Start	After 1 hr.	After 1½ hr	After 2 hr	After 1 hr	After 1½ hr	After 2 hr	After 1 hr	After 1½ hr	After 2 hr		
19 a	248	228		113	20		135	8.1		54.4	20.5°C.	72%
19 b	244	223		110	21		134	8.7		54.9	"	"
19 c	250	225.5		114	24.5		136	9.8		54.4	"	"
Av.	247.3	225.5		112.5	21.8		135	8.8		54.6		
20 a	237	237		133	0		104	0		43.9	20.5°C.	72%
20 b	234	234		138	0		96	0		41	"	"
20 c	232.5	232.5		137	0		95.5	0		41.1	"	"
Av.	234.5	234.5		136	0		98.5	0		42		
21 a	239	223	153	93	16	86	146	6.7	36	61.1	21°C.	72%
21 b	251	231	167	101	20	84	150	8	33.5	60	"	"
21 c	246	225	159	98	21	87	148	8.5	35.4	60.1	"	"
Av.	245.3	226.3	161	97.3	19	85.7	148	7.7	35	60.4		
22 a	234	234	192	130	0	42	104	0	17.9	44.4	21°C.	72%
22 b	246	246	188	135	0	58	111	0	23.6	45.1	"	"
22 c	241	241	188	132	0	53	109	0	22	45.2	"	"
Av.	240.3	240.3	189.3	132.7	0	51	108	0	21.2	44.9		

Composition of Mixes in Table 9

Fat %	M.S.N.F. %	Sugar %	Gelatin %	T. S. %	Lbs.40% Cream	Lbs. Skim	Lbs. Cond.	Lbs. Water
8	18	12	.5	38.5	10	----	31.1	2

All the mixes in Table 9 had the above composition. Mixes 19 and 21 contained unsuperheated condensed milk, while mixes 20 and 22 contained superheated condensed milk.

It is evident from these data that ice cream containing superheated condensed milk will stand up much better when subjected to temperatures above freezing than will that in which unsuperheated condensed milk is used, the amount of difference depending upon the quantity of condensed milk used.

It will be noted that in Table 8 the difference between samples 13 a, b, c and 14 a, b, c in the percentage melted is very slight, whereas the difference is greater between samples 13 a, b, c and 15 a, b, c, showing how an increase in the amount of superheated condensed milk increases the ability of the ice cream to stand up when subjected to temperatures above freezing.

Batches 16, 17, and 18 show a wider range in the percentages melted, and the increase in heat resistance due to the use of increased amounts of superheated condensed milk is more noticeable.

The data in Table 9 show the heat resistance of ice cream containing a comparatively large percentage of milk solids not fat, and in which 31.1 pounds of condensed milk were used in each 50-pound batch. Referring to batches 19 and 20, it is seen that the use of superheated condensed milk resulted in an average reduction of 23.1 percent in the amount melted at the end of two hours. Similar results were obtained in comparative batches 21 and 22, in which the amount of reduction at the end of the same period was 25.6 percent.

The difference in the way in which comparative batches of ice cream melted is also shown in the following pictures taken of the samples recorded in Tables 8 and 9. Picture No. 1 represents the appearance of all the samples at the start of the experiment. Picture No. 2 shows the difference in amounts melted from samples 19 a (on the left) and 20 a (on the right) at the end of one hour's exposure to room temperature.

Picture No. 3 taken of samples 16 a, 17 a, and 18 a at the end of one hour also clearly shows how the increase in amount of superheated condensed milk

Pictures Taken of Samples Recorded in Tables 6 and 7, Showing the Difference in Heat Resistance of Ice Cream Containing Superheated Condensed Milk and That Containing Unsuperheated Condensed Milk.

The appearance of all the samples at the start of the experiment

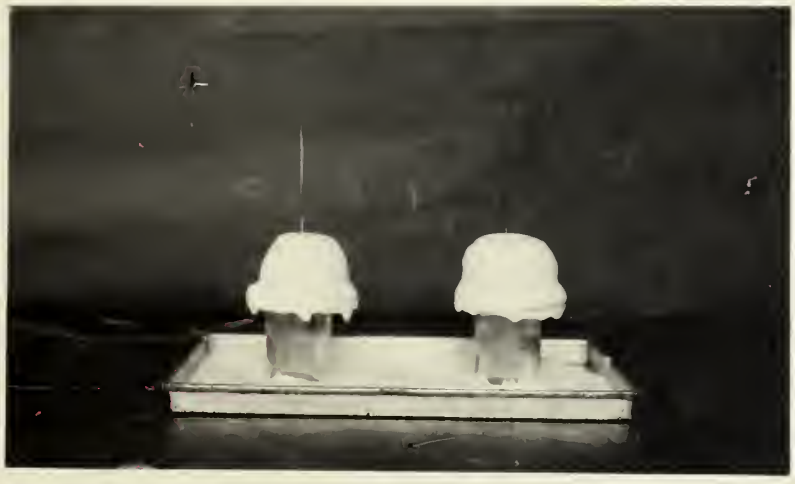
Picture No. 1

Samples 19a (on the left) and 20a (on the right) at the end of one hour's exposure to room temperature

Picture No. 2

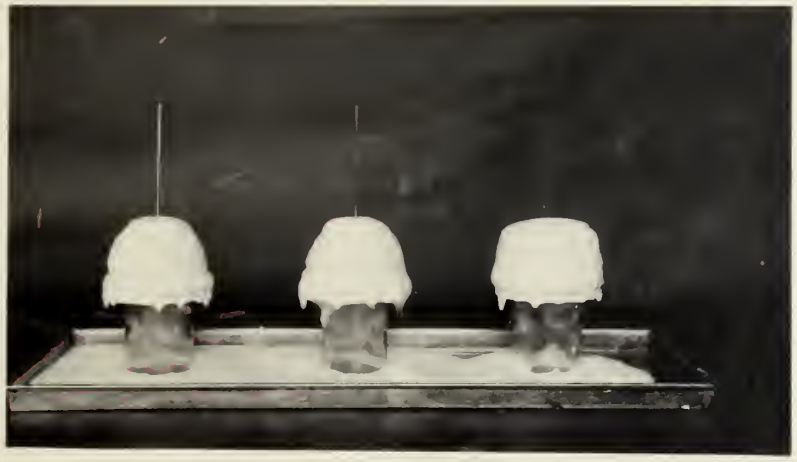
Samples 16a (on the left) 17a (center) and 18a (on the right) at the end of one hour's exposure to room temperature

Picture No. 3



Samples 19a (on the left) and 20a (on the right) at the end of two hours' exposure to room temperature

Picture No. 4



Samples 16a (on the left), 17a (center) and 18a (on the right) at the end of two hours' exposure to room temperature

Picture No. 5

used increases the ability of the ice cream to stand up. The composition of all three batches was the same, the only difference being the condensed milk used. In the sample on the left 9.3 pounds of unsuperheated condensed milk was used; in the middle sample 9.3 pounds of superheated condensed milk was used; while in the third sample 15.9 pounds of superheated condensed milk was used. The difference in the percentage melted from the first two samples is hardly noticeable, being 1.1 percent. However, the difference between either the first or second and the third is more striking. The percentage melted in the first case was 5.2; in the second, 4.1; whereas only three drops had fallen from the third sample when the picture was taken.

Picture No. 4 shows samples 19 a and 20 a at the end of two hours. By this time 54.4 percent of 19 a had melted but only 43.9 percent of 20 a had melted.

Picture No. 5 shows samples 16 a, 17 a and 18 a at the end of two hours. As in Picture No. 3, the appearance of the samples 16 a (left) and 17 a (center) is about the same, the difference in the percentage melted being 8.3. When sample 16 a and 18 a (right) are compared, however, a greater difference can be seen, the difference in the percentage melted being 17.9.

Both the data and the pictures show rather conclusively that the use of superheated condensed milk causes the ice cream to have more resistance to temperatures above the freezing point, the ice cream having the greatest resistance being that containing the greatest amount of the superheated condensed milk.

CONCLUSIONS

1. Superheating condensed skim milk causes the albumin to be changed from a colloidal to a precipitated form.

2. The use of superheated condensed milk increases the viscosity of the ice cream mix.

3. The use of superheated condensed milk improves the texture and body of the ice cream and increases its resistance.

4. Ice cream containing unsuperheated condensed milk has a better flavor than that containing superheated condensed milk.

5. A larger over-run can be obtained from mix containing superheated condensed milk than from mix containing unsuperheated condensed milk.

6. An ice cream containing superheated condensed milk will have a greater heat resistance than that containing unsuperheated condensed milk.

REFERENCES

1. L. L. Van Slyke. Modern Methods of Testing Milk and Milk Products. Page 16.

2. W. W. Fisk. The Book of Ice Cream. Pages 240-242, 134.

3. Zsigmondy, Spear. Chemistry of Colloids. Pages 236-238, 10-11.

4. Bechhold. Colloids in Biology and Medicine. Pages 173-176, 345-351.

5. H. D. Richmond. Dairy Chemistry. Pages 39-65, 414.

6. O. F. Hunziker. Condensed Milk and Milk Powder. Pages 162-166.

7. R. Scherer. Casein - Its Preparation and Technical Utilization. Page 15.

8. Mojonnier Bros. Cream Table.

ACKNOWLEDGMENT

The author wishes to take this means of expressing his thanks to Professors H. A. Ruehe and O. R. Overman and Mr. A. S. Ambrose, who assisted in the judging of the ice cream. Thanks are also due to Professors Overman and Ruehe for their helpful criticisms in the preparation of this thesis.

UNIVERSITY OF ILLINOIS-URBANA
3 0112 077506738